



U.S. MAGNET
DEVELOPMENT
PROGRAM

ReBCO Roadmap

MDP Video meeting on October 23, 2019

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U.S. DEPARTMENT OF
ENERGY

Office of
Science

Background

A few thoughts on the high field HTS magnet technology program for MDP

- It needs to have a long term horizon. But should address/answer key technical questions regularly
 - We shouldn't have to wait several years to get one data point
- Specific demonstrations generally require a specific geometry. But still we should be able to develop the overall R&D program in such a way that it answers key technical questions for most designs. Examples:
 - Quench studies for a robust quench protection
 - HTS/LTS hybrid dipole operation
 - Field quality (magnetization) - need a dialogue with beam physicist
 - High stress/strain on the conductor due to large Lorentz forces
- It should have yearly goals. But must not loose sight of the ultimate goal
 - Need to review/develop both short term goals (yearly) and long term goals

Then we should also have specific R&D on developing conductor/cable and magnet designs that are more suitable for high field HTS dipole technology

Suggested Approach

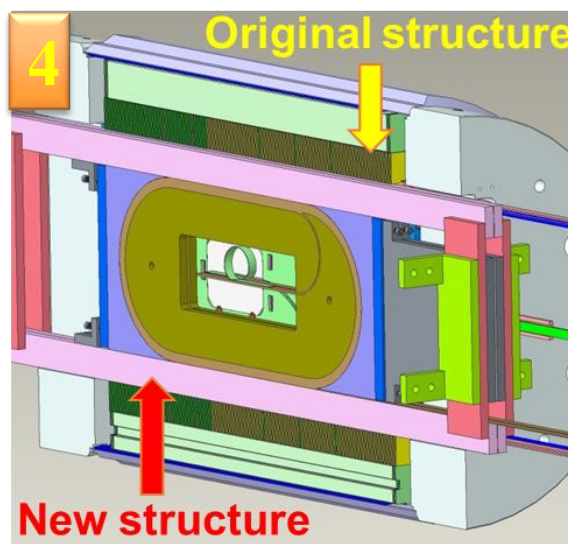
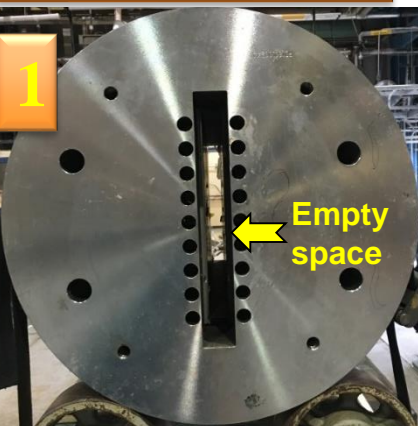
- Perform R&D or technology development tests through experimental demonstration at 10 T or more (when available)
- Perform components of magnet design tests through experimental demonstration at 10 T or more (when available)

Testing of HTS Coil Technology @High Fields (rapid turn-around, low cost)

Five Steps:

Replaceable R&D Coil(s)

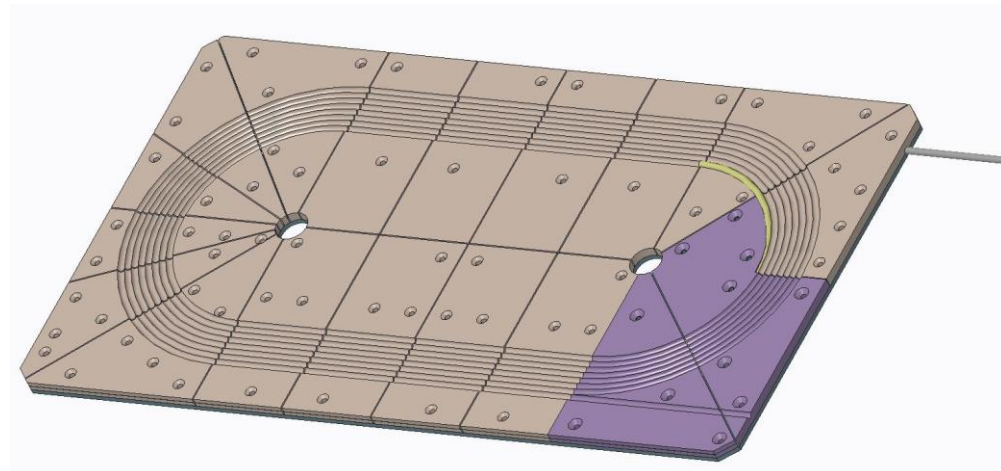
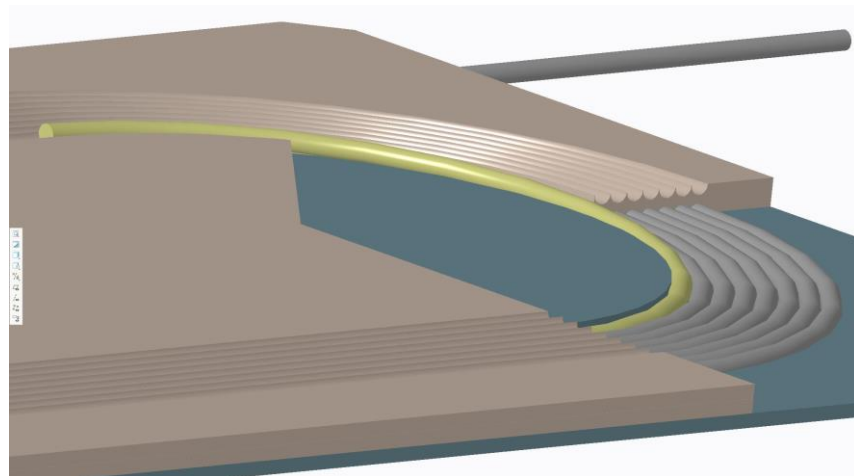
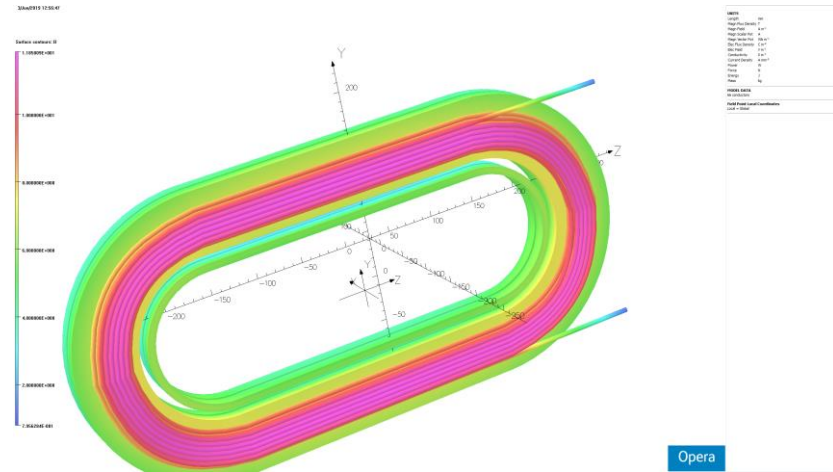
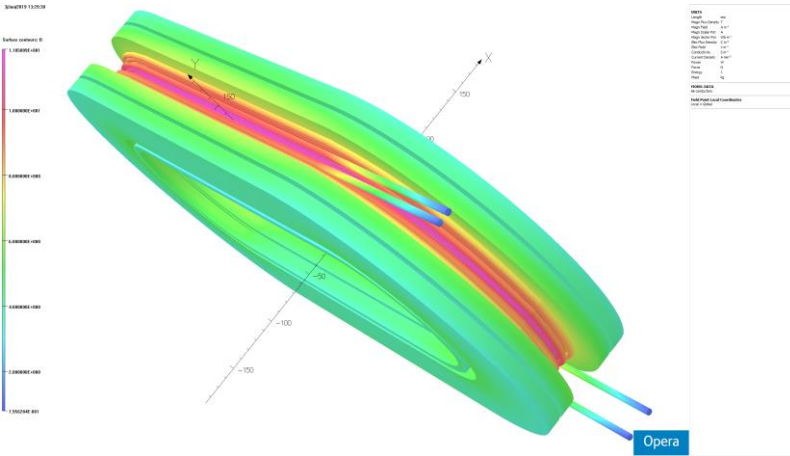
1. Magnet (dipole) with a large open space
2. R&D Coil for high field testing
3. Slide coil in the magnet
4. Coils become an integral part of the magnet
5. Magnet with new coil(s) ready for testing





- Use of cable offers significant advantages
- CORC base coils are being considered by all three labs in different configurations
- While there are differences, some fundamental issues are similar
 - Quench protection?
 - Ability of CORC cable coil to withstand large high loads under Lorentz forces?
 - Field errors?
- **MDP is supporting quench studies at BNL with the participation of LBL**
 - Expect feedback within a year (try different quench detection/protection techniques)
 - Iterate/expand program based on the initial results (continue from year 2 to 5?)
- **BNL has a SBIR to study magnet issues in CORC HTS/LTS hybrid dipole**
 - Expect feedback in 1-2 years on field achieved (field error study as a part of MDP?)
 - SBIR goal is ~4 T field over 10 T Nb₃Sn (Total ~14 T)
 - Based on the results, MDP can augment it to 5+ T (year 3 to 5) to meet it's 5 T goal

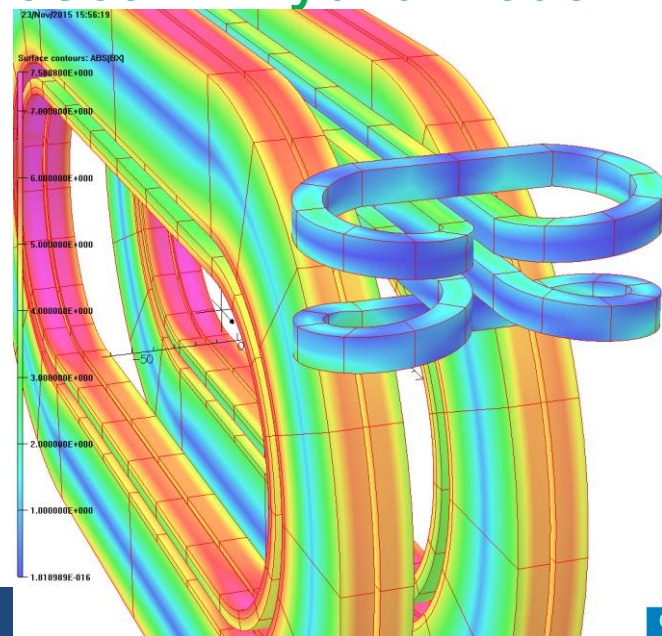
Field on the Hybrid coils at 10 kA (1) (6 & 8 turn CORC cable coil with Nb₃coils)



Freeway Overpass/UnderPass (or clover-leaf) Ends for High Field HTS Dipoles



- CERN is pursuing Freeway Overpass/UnderPass (or clover-leaf) design with Roebel
- USMDP can do it with CORC and/or stacked tape cable
- Test that coil in hybrid mode





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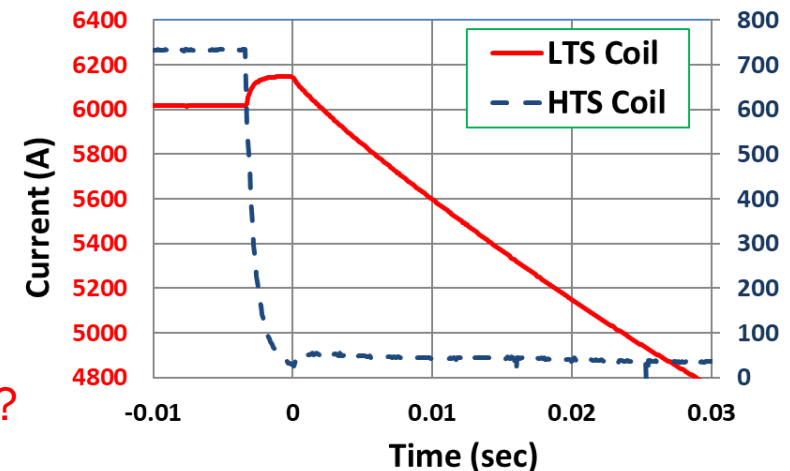
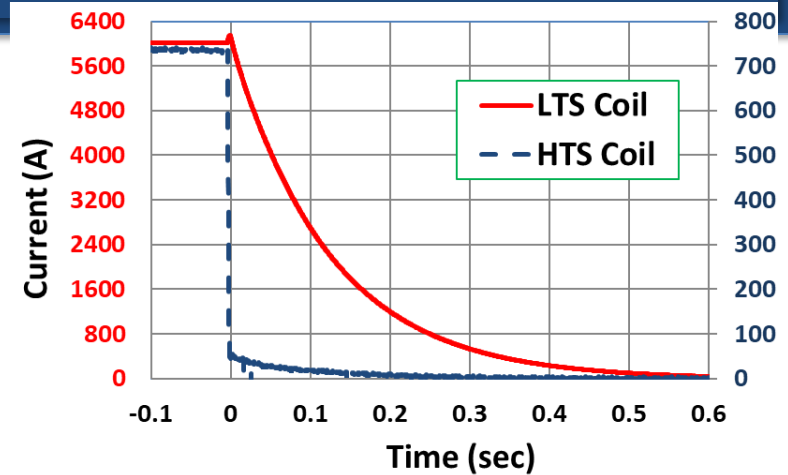
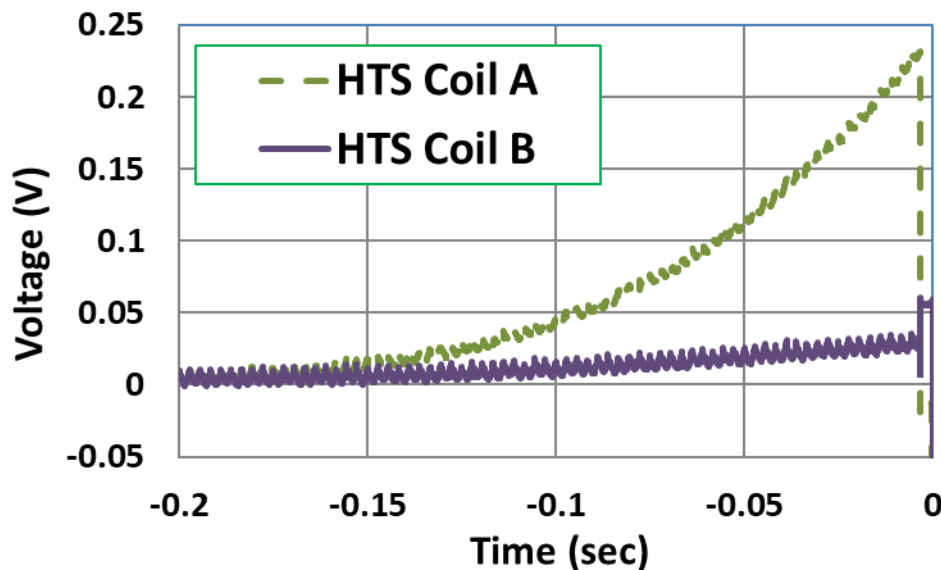
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Quench Protection of HTS/LTS Hybrid Dipole



Feedback of Quenching of HTS Coils on LTS Coils in HTS/LTS Hybrid Magnet

- HTS coils operated like HTS coils
- Significant voltage in HTS coils



What happens when the energy of HTS coil increases?
Or what happens to HTS coils if LTS coil quenches?

Study of coupling between HTS & LTS
coils can be a major part of MDP



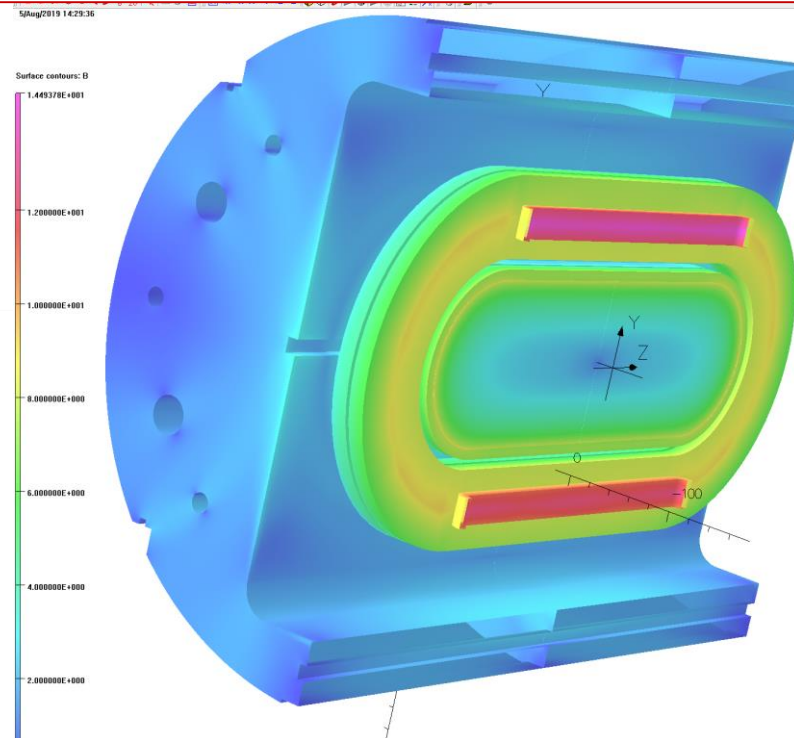
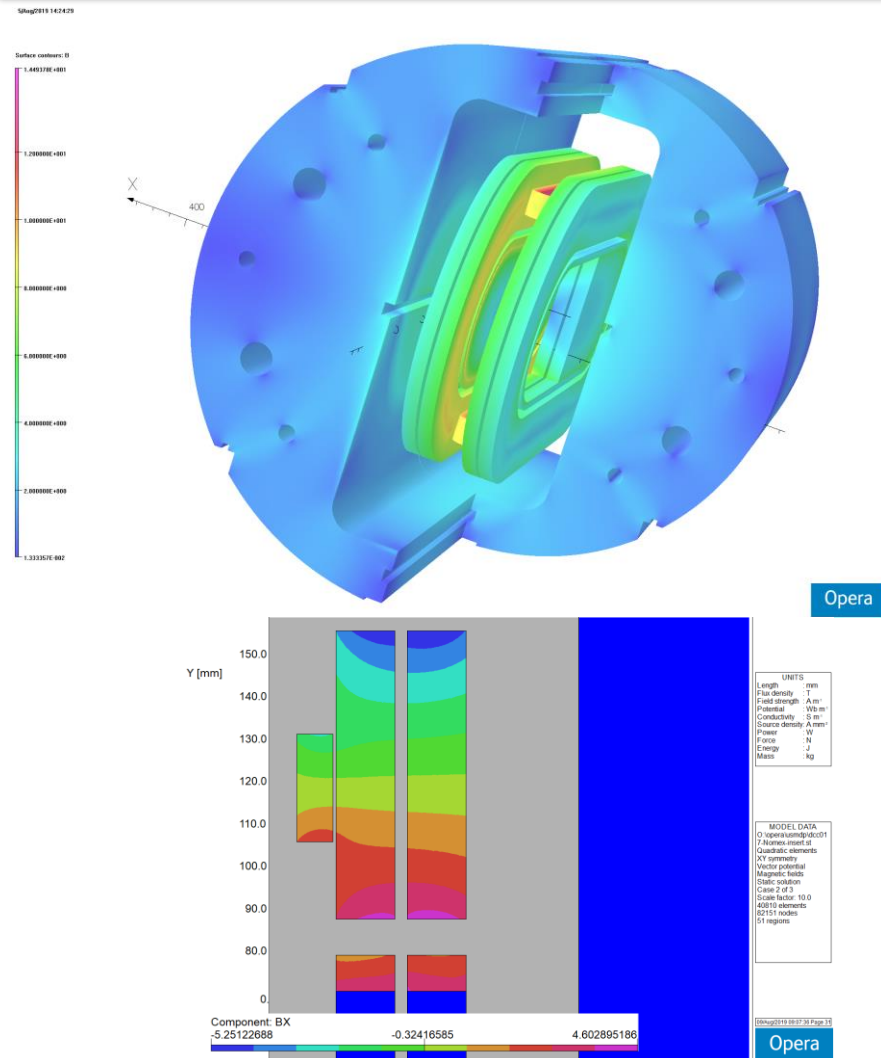
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Magnetization Studies for USMDP

Magnetization or Field Error Studies from HTS Coils

**BNL Common coil dipole can provide
a variable and significant
background dipole field for coils
made with different HTS tape/cable**





Current Status



- As a part of current MDP, HTS coils are built for magnetization studies (BNL/LBL/OSU collaboration).
- They will be tested in the background field within a few months (next available opportunity).
- Apart from the magnetization studies, quench studies will also be performed.

Summary

- We are trying to put together REBCO roadmap.
- The general goals are 5 T HTS dipole field and 20 T hybrid field. These goals may be revisited.
- The roadmap must have some specific technical targets. It should also have some specific timelines.
- Timeline and targets should be consistent with the funding available. But since the funding is uncertain, those targets and timelines will need to be adjusted.
- **Given the reasons mentioned in the background slide, the ReBCO program should be broad at this stage but with specific technical goals. We should look for common areas to collaborate.**